Examination of optimum shape of Savonius wind turbine with different number of blades using CFD technology

CFD: Computational Fluid Dynamics

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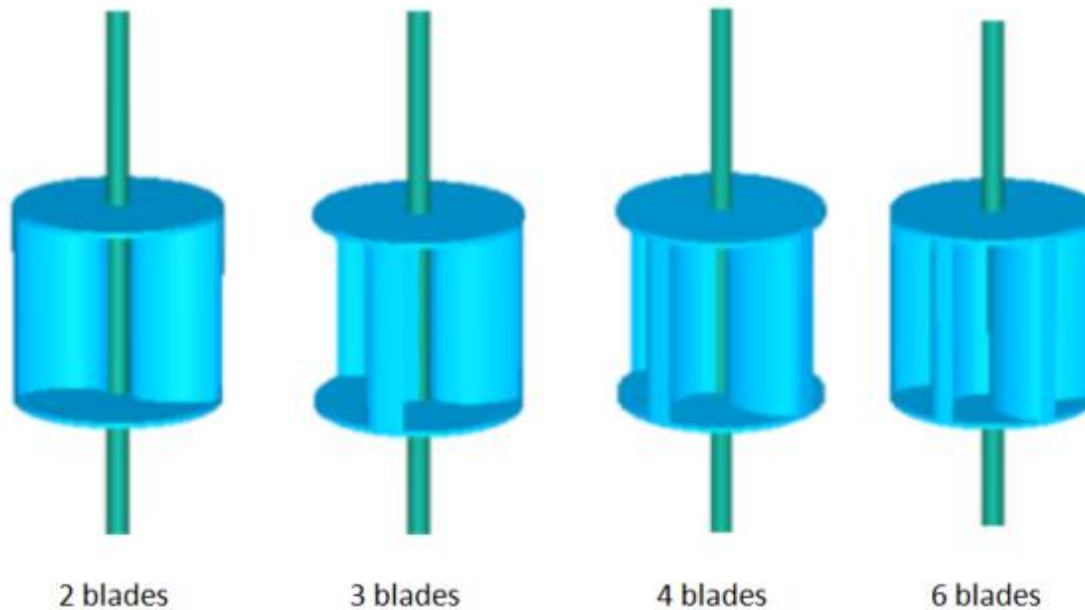
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GUNMA UNIVERSITY

Research Objective

Different Number of Blades
Savonius Wind Turbine

2 blades   3 blades   4 blades   6 blades

Which is the optimal shape ?

Contents

- **Research Background**

- **Definition of the shape of the wind turbine**

- **Numerical Method**

- **Results**

- **Conclusion**

Contents

Research Background

Global warming

⬇

The use of
・Renewable energy
・Decentralized power
 generation

⬇

Wind power generation

The research aim:
 Small wind turbine simulator
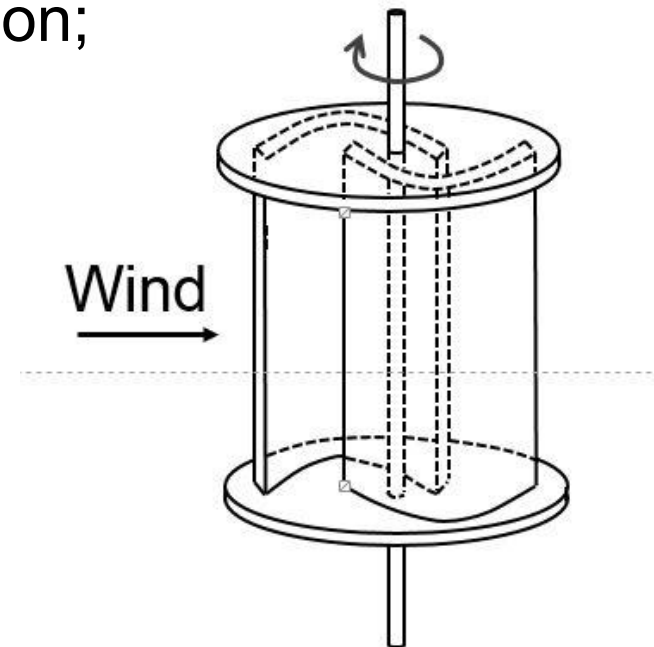 for complex wind conditions
 in Japan

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Target wind turbine of this research

Savonius wind turbine (one of vertical axis type)
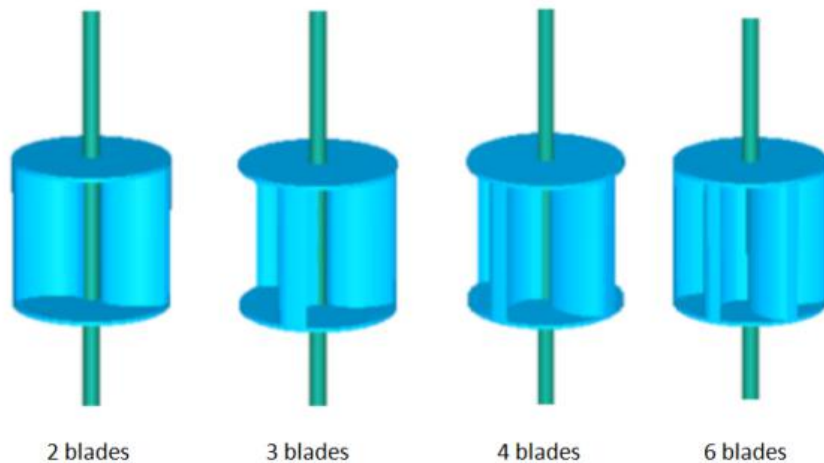
Advantage of Savonius wind turbine

・simple construction with low cost;

・wind acceptance from most direction for the operation;

・low noise and angular velocity in operation;

・reduced wear on moving parts;

・various rotor configuration options;

・high static and dynamic moment

Wind

Blade definitions

To investigate the self-starting ability...

1. Wind blows from an angle to the stopped wind turbine.
2. Calculate torque coefficient.
3. Plot on the graph.
4. Wind blows from the other angle.
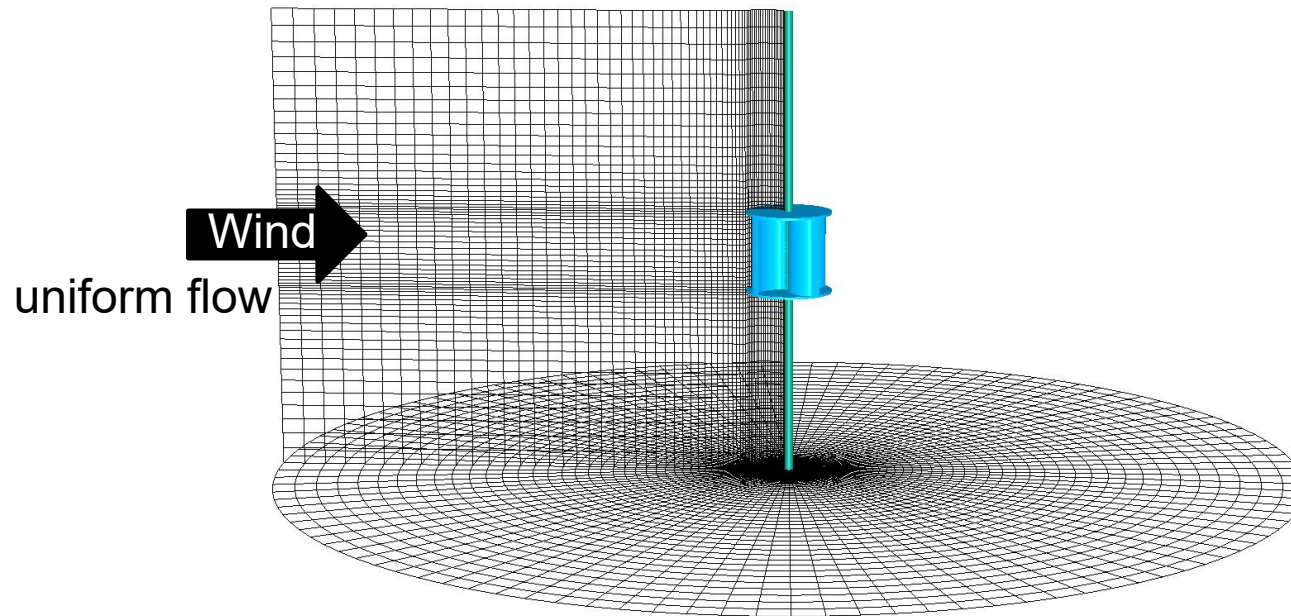   This angle is defined as "Attack Angle".
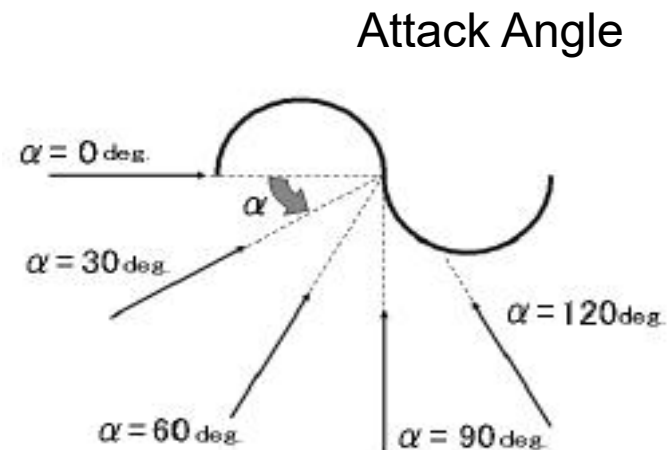
Attack Angle

$\alpha = 0$ deg.

α

$\alpha = 30$ deg.

$\alpha = 120$ deg.

$\alpha = 60$ deg.

$\alpha = 90$ deg.

2 blades   3 blades   4 blades   6 blades

Which is the optimal shape ?

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Calculation area / Boundary condition

Wind

uniform flow

The number of grids:
  circumferential 110 × radial 60 × height 60.

Boundary conditions:
  Far boundary : a uniform flow
  On the turbine blade: no-slip

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Torque coefficient

Torque is the force to rotate the wind turbine.
Used as the index for investigate the optimal shape.
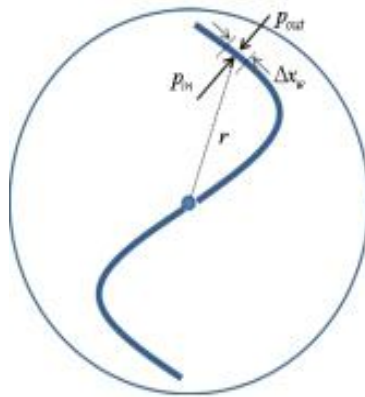
(a) Torque applied to the blade.
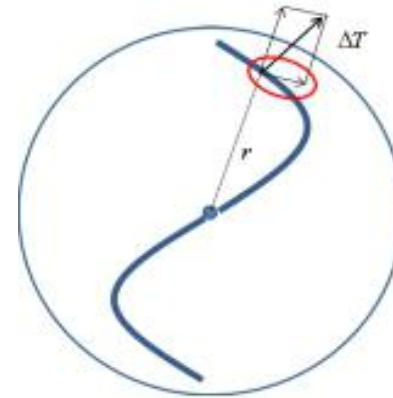
(b) Component of rotation direction of torque.

The torque involved in the micro area Δx_w : $\Delta T = \Delta x_w (p_{in} - p_{out})r$
The total torque T : $T = \sum \Delta T$ (Addition of all ΔT on the blade)
The torque coefficient Ct: $Ct = \dfrac{T}{qRA}$
$\quad$ (non-dimensionalized torque by the size of wind turbine)

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Starting characteristics
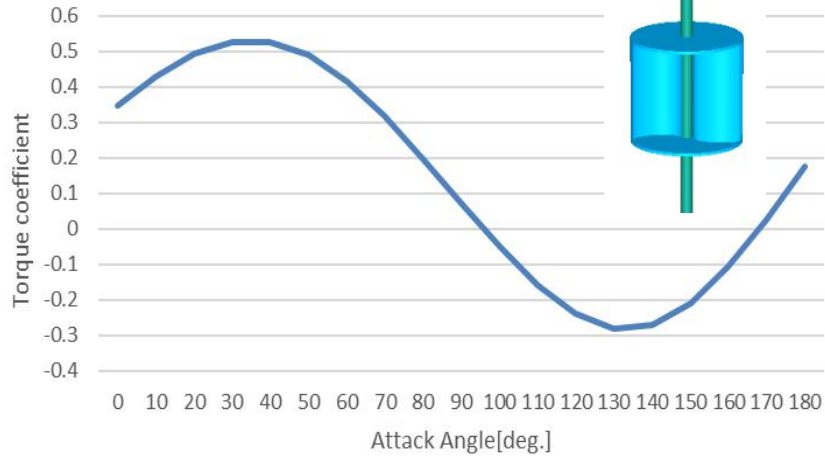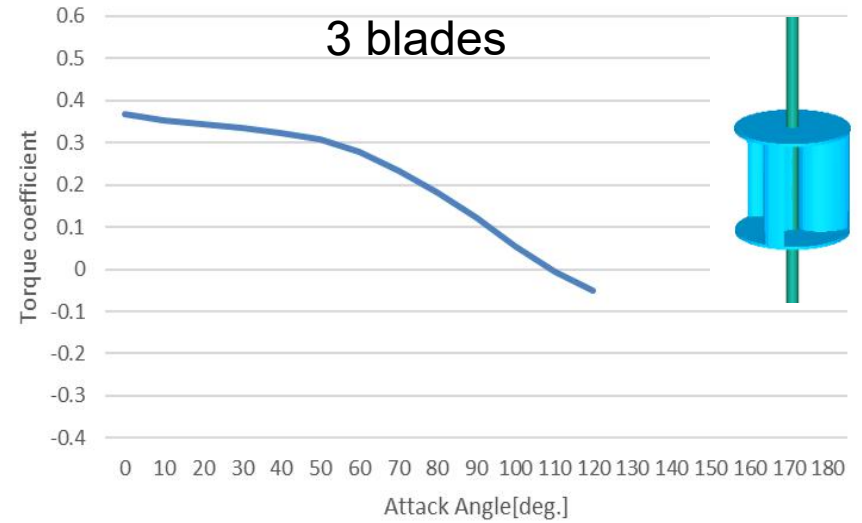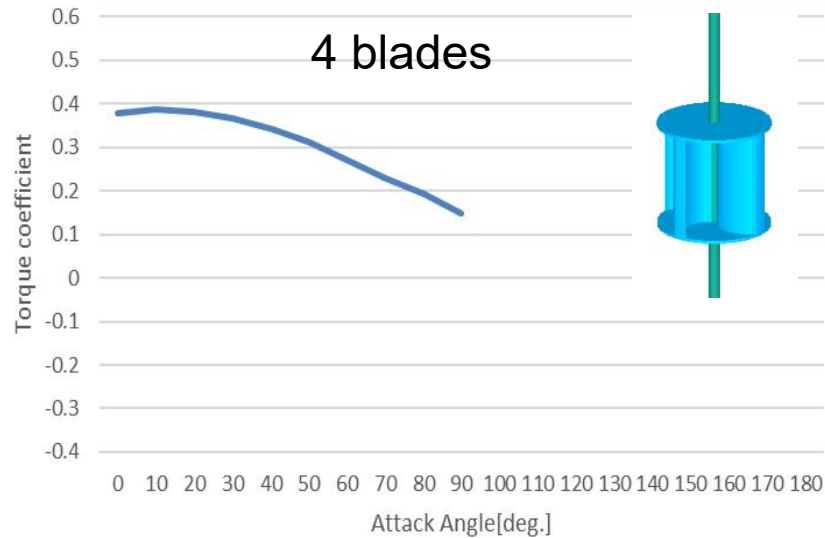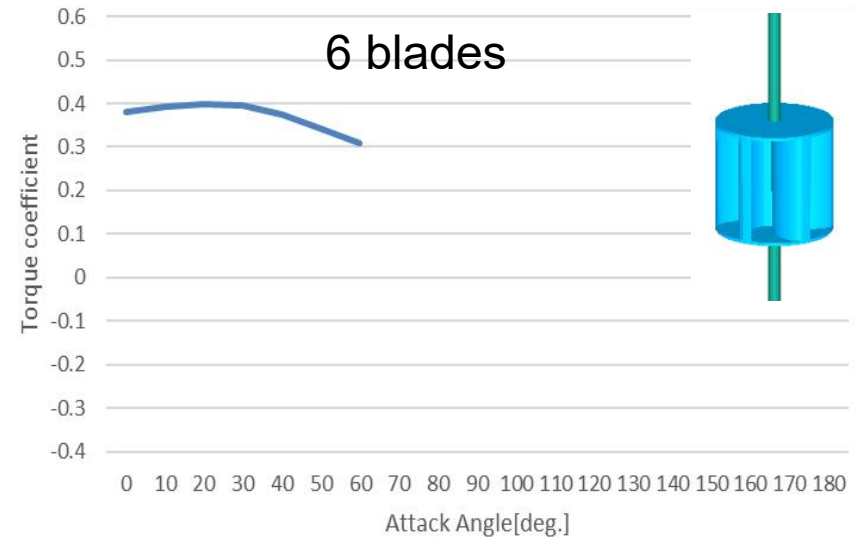
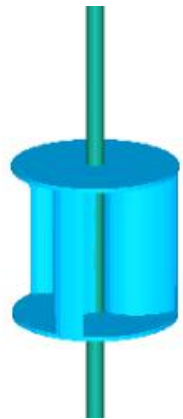# Starting characteristics of the 2 blades wind turbine
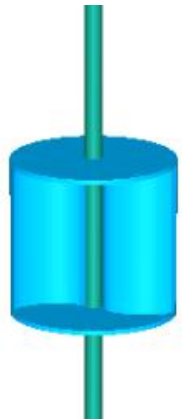
2 blades
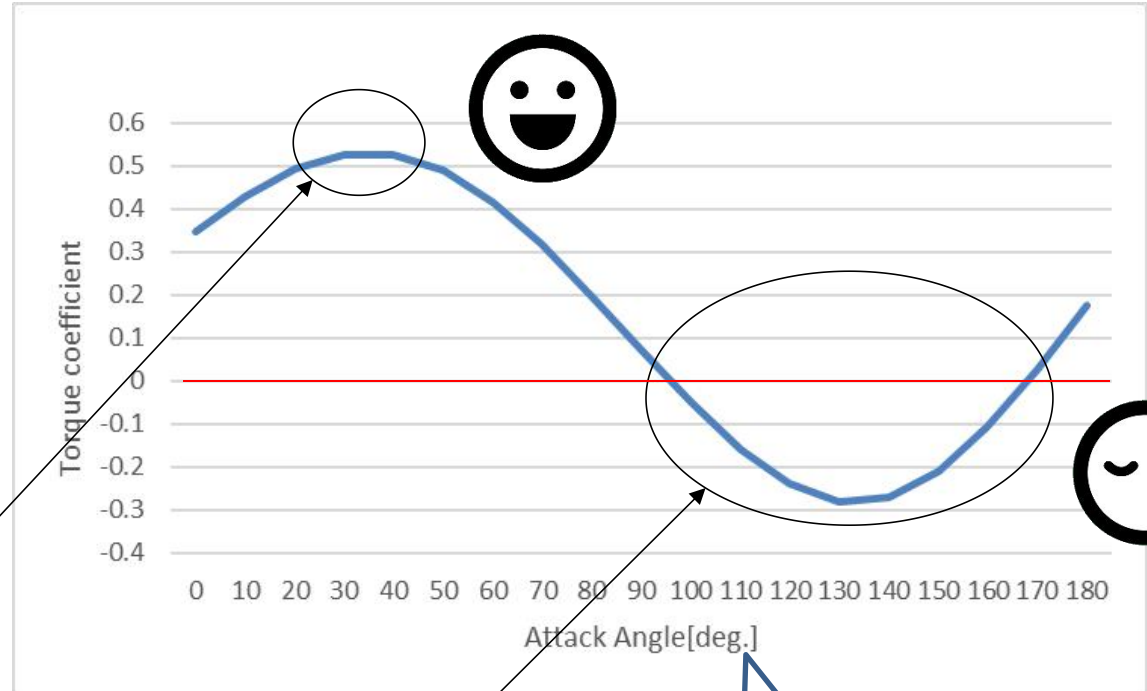
Torque coefficient is large
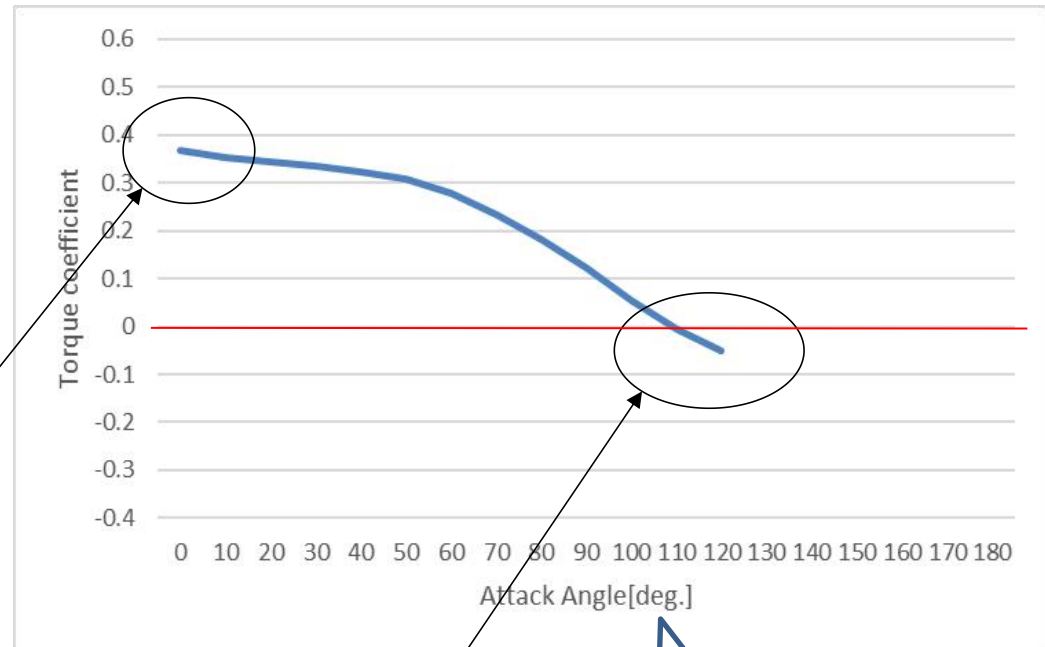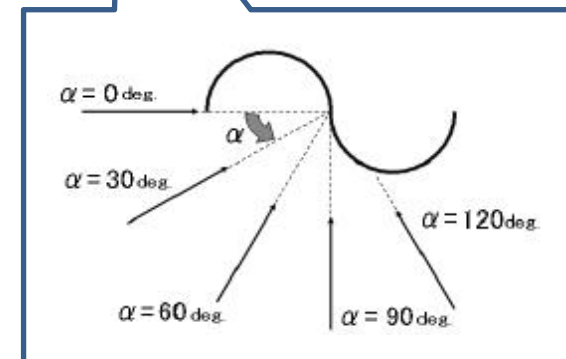@Attack Angle = near 30 degrees

Static torque is negative.
→turbine cannot to start to rotate
@Attack Angle = 100～170degrees.
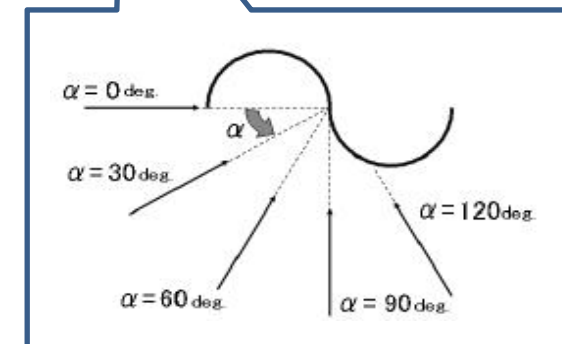
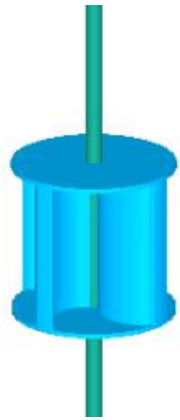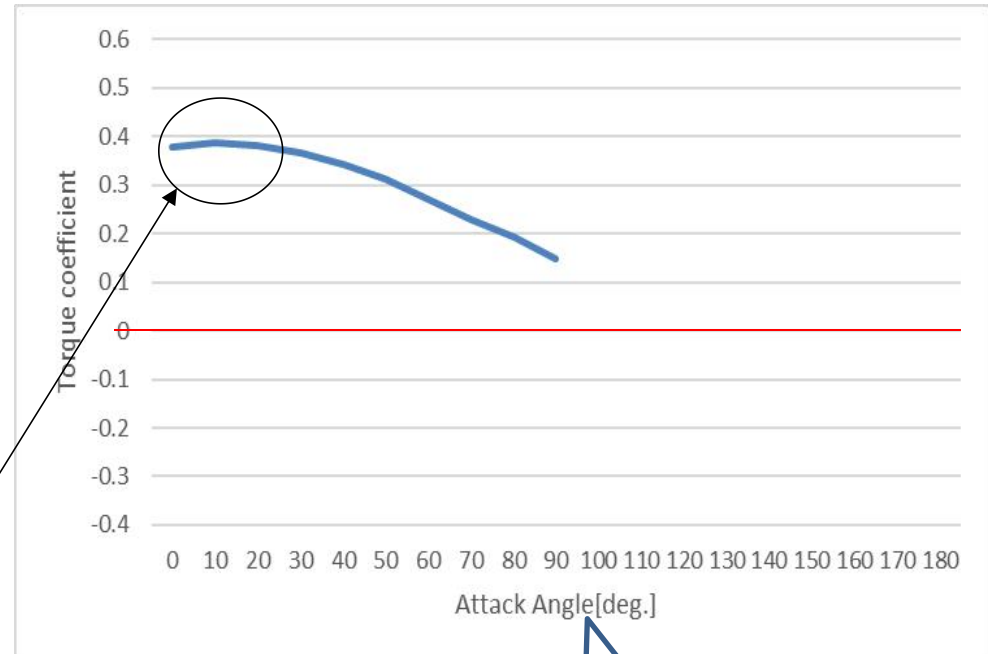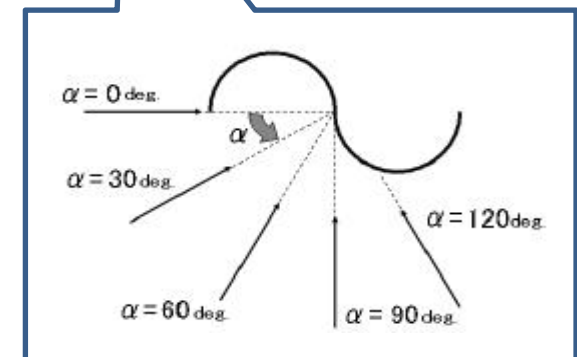# Starting characteristics of the 3 blades wind turbine

3 blades

Torque coefficient is large
@Attack Angle = near 0 degrees

Static torque is negative.
→turbine cannot start to rotate
@Attack Angle =110〜120degrees.

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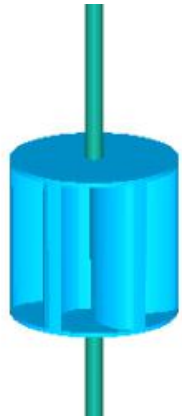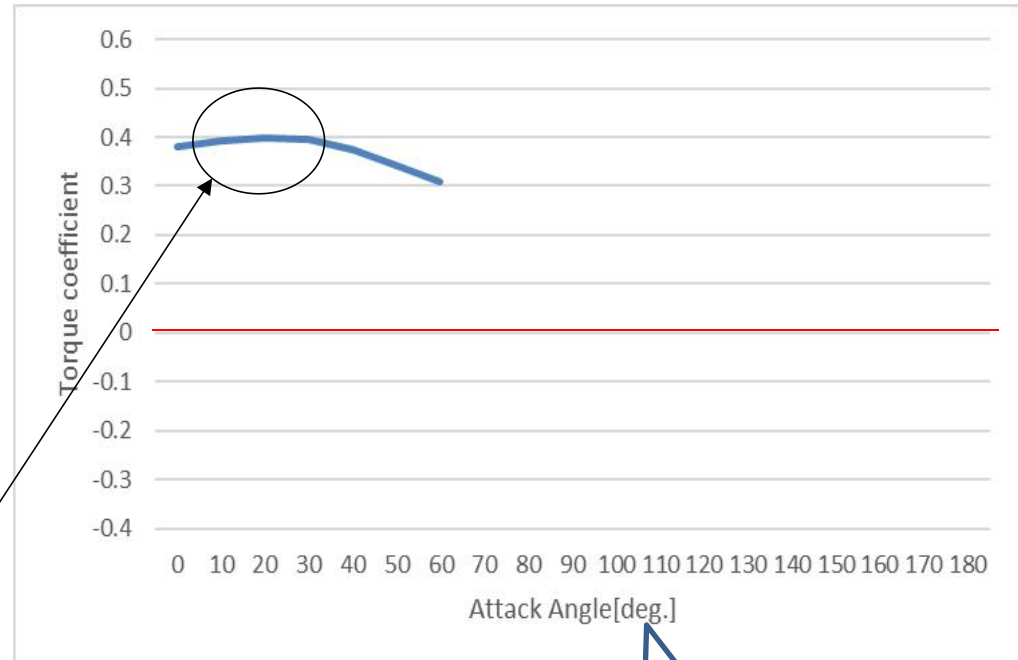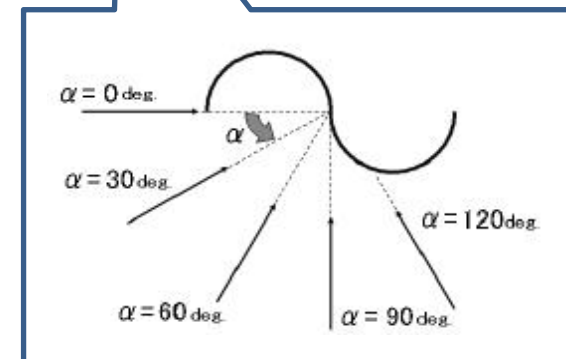# Starting characteristics of the 4 blades wind turbine

4 blades

Torque coefficient is large
@Attack Angle = near 10 degrees

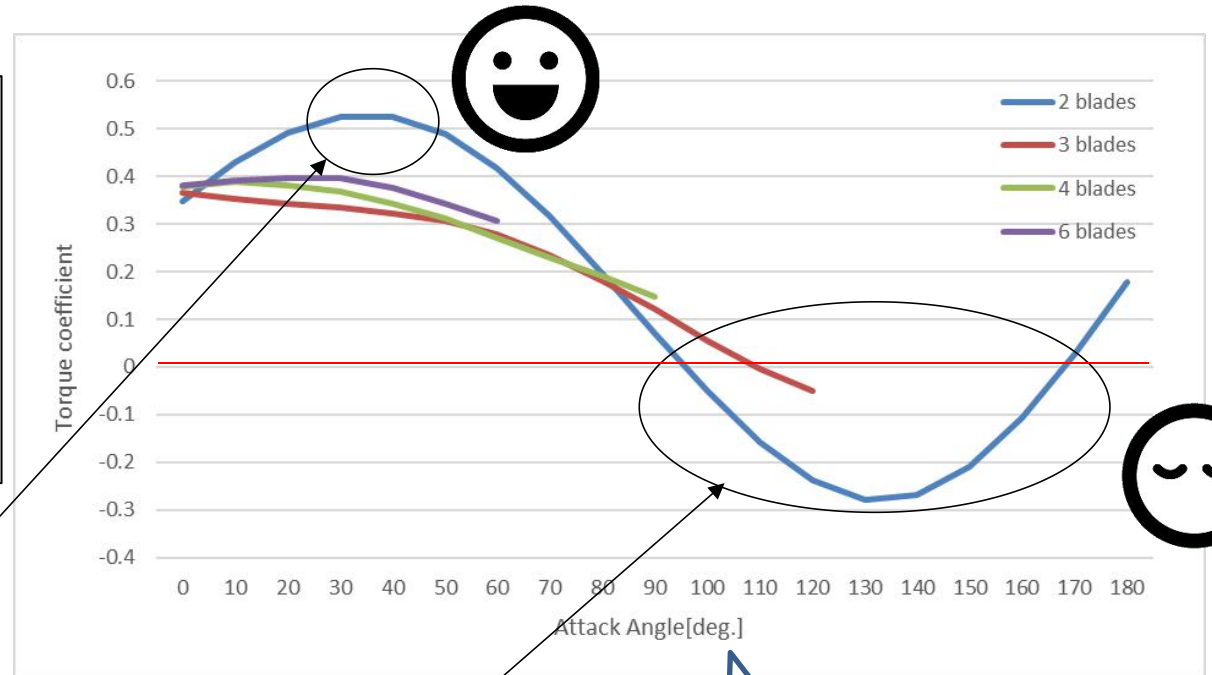# Starting characteristics of the 6 blades wind turbine

6 blades

Torque coefficient is large
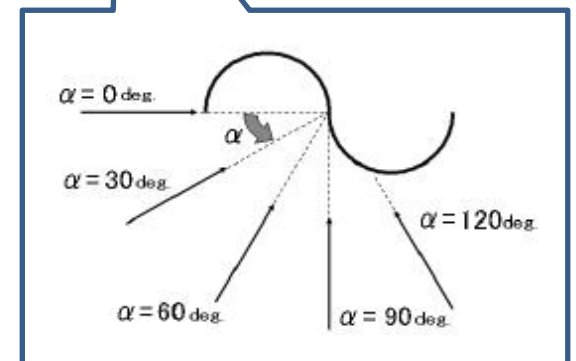@Attack Angle = near 20 degrees

Starting characteristics of all wind turbines are compared

The torque coefficient is small for the 4 and 6 blades, however there is no negative torque.

The 2 blades turbine has the largest torque coefficient

The Attack Angle is from100 to 170 degrees, the torque coefficient is negative, the wind turbine cannot be started to rotate. The 3 blades turbine has also negative torque coefficient.
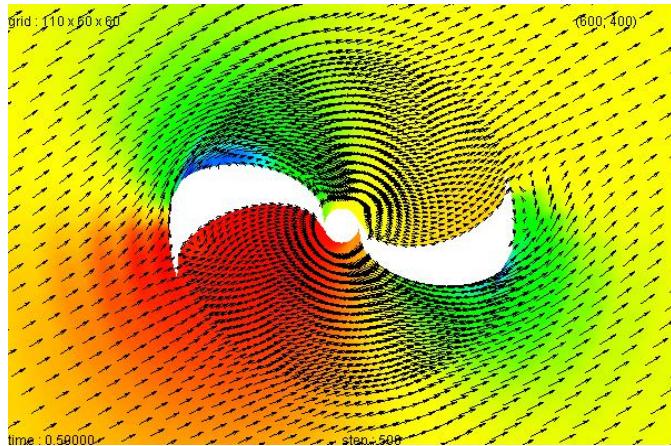
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Mechanism of Rotation

Low
pressure

Rotate

High
pressure

Wind

Low
pressure

**Cannot
rotate**
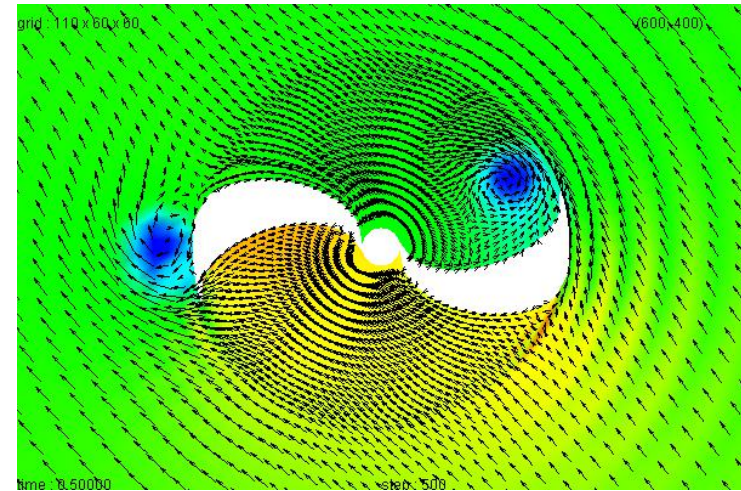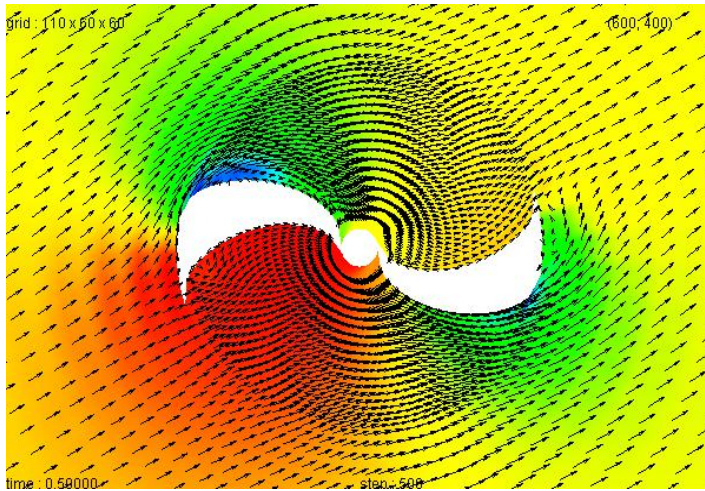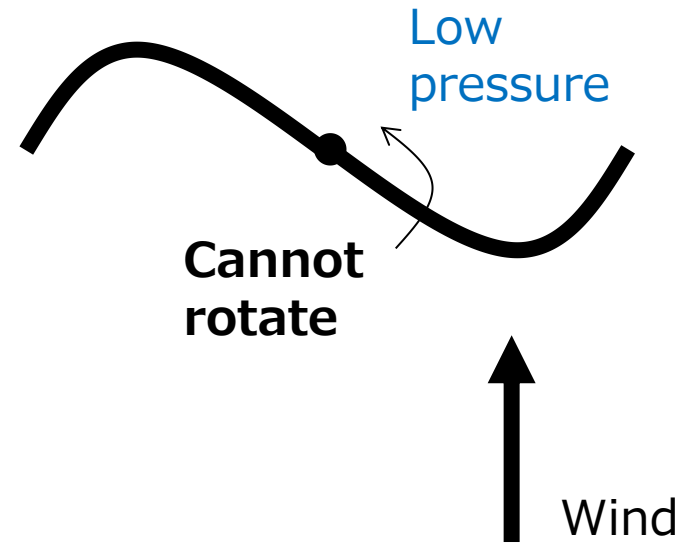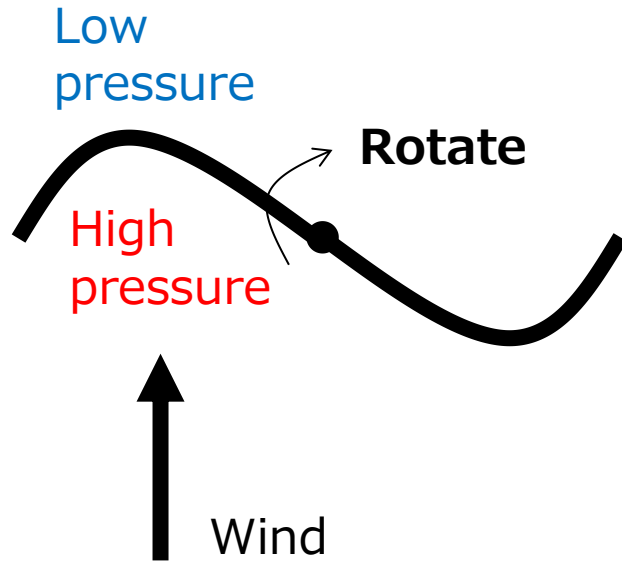
Wind

Pressure field and velocity vectors

At the largest torque coefficient is generated.

Pressure(non-dimentional)
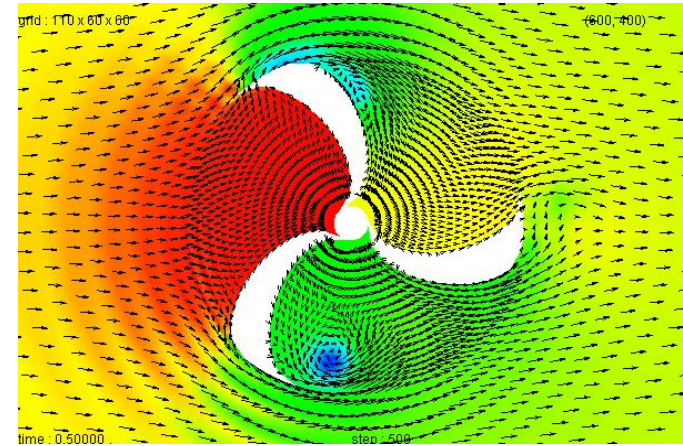
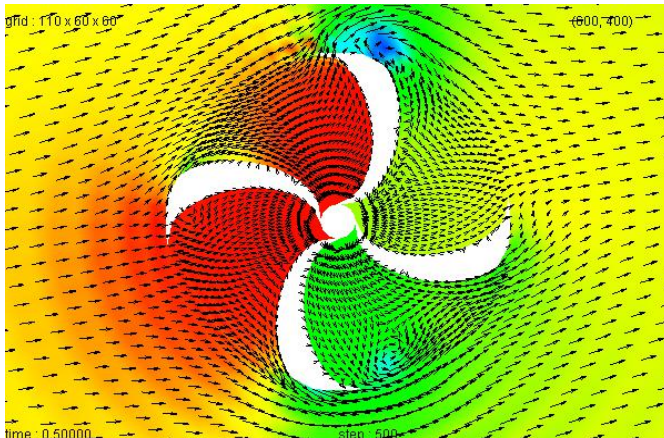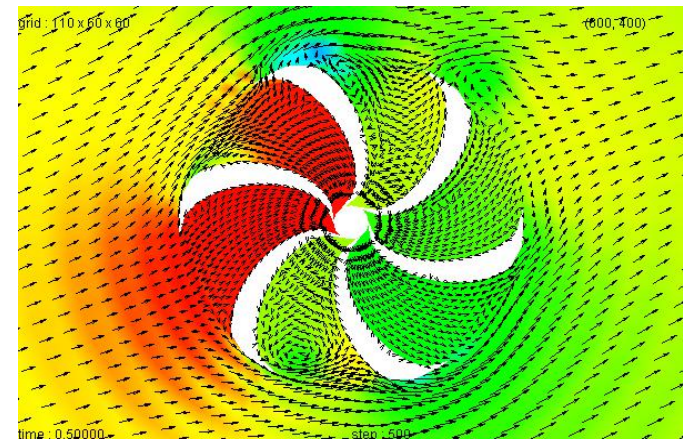## 2 blades

3 blades

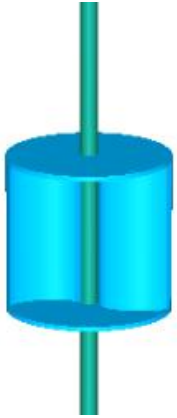## 4 blades

6 blades

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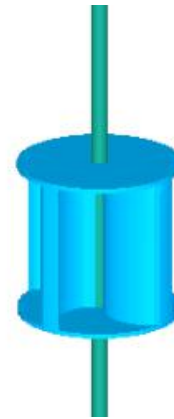
● **Conclusion**

Conclusion

2 blades

Generates a strong torque
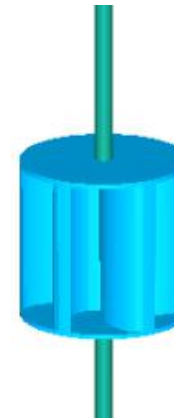when the wind hits it
from a specific angle. 😃

It is necessary to adjust
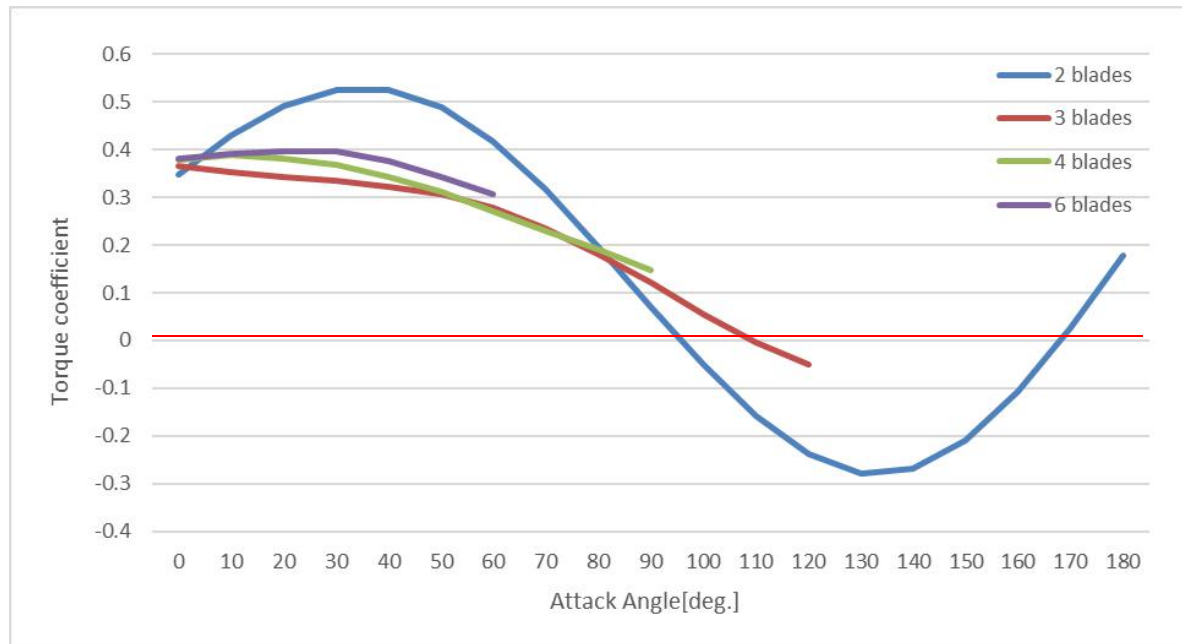the wind direction. 😌

4 blades 6 blades

Start rotating
regardless of the
angle of the wind.
😃

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ご清聴ありがとうございました

Thank you for listening

謝謝